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## Disclosure of unnoticed rib fractures with the use of ultrasonography in minor blunt chest trauma

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### Abstract

**Objective:** Rib fractures are the most common injuries resulting from blunt chest trauma. The sensitivity of chest X-rays in showing the rib fractures is limited particularly in those involving the cartilage part of the rib. We investigated the possible rib fractures, those overlooked on chest X-rays, with the use of ultrasonography in minor blunt chest trauma. **Methods:** A total of 37 patients, with minor blunt chest trauma showing no evidence of a rib fracture on chest X-rays, were examined with ultrasonography performed with a 7.5-MHz linear transducer. Logistic regression analysis was done to outline the clinical predictors of these insidious rib fractures. **Results:** A total of 15 (40.5%) patients showed rib lesions, whereas 22 (59.5%) patients had no evidence of rib lesions. Fracture of the rib associated with a subperiosteal hematoma was the most common finding in ten (66.7%) patients followed by the fracture of the rib alone in four (26.7%) patients, and subperiosteal hematoma alone in one (6.7%) patient. A total of eight (53.3%) patients had bony rib fractures, whereas seven (46.7%) patients had chondral rib fractures. Age ( $P = 0.617$ ), gender ( $P = 0.552$ ), type of etiology ( $P = 0.954$ ), duration of pain ( $P = 0.234$ ) and site of trauma ( $P = 0.740$ ) did not appear as significant predictors for these rib fractures. However, the involved part of the rib showed a significant correlation with either age ( $P = 0.042$ ) or duration of pain ( $P = 0.033$ ). Bony rib fractures significantly occurred in elderly patients, and the duration of pain in patients with bony rib fractures was significantly longer than that of patients with chondral rib fractures. **Conclusions:** Ultrasonography is a useful imaging method in showing the rib fractures those overlooked on chest X-rays in minor blunt chest trauma, and no significant clinical feature exists as a predictor for these insidious fractures. However, bony rib fractures significantly occur in elderly patients and result in a longer duration of pain.

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**Keywords:** Chest trauma; Rib fracture; Ultrasonography

### 1. Introduction

Blunt chest trauma accounts for 81% of thoracic injuries in children and 78% in the elderly, and minor blunt chest trauma is the most common form of blunt chest trauma [1]. Minor blunt chest trauma comprises more than half of the rib fractures without any complications such as pneumothorax, hemothorax or pulmonary contusion, and is often treated on an outpatient basis [2,3]. Although the findings in blunt chest trauma have a wide range including multiple rib fractures with flail chest and associated underlying visceral injury, the most common clinical diagnosis is often soft

tissue injury in minor blunt chest trauma [3]. Nevertheless, many thoracic surgeons may encounter patients with long-standing pain despite a proper treatment for soft tissue injury, which may indicate the necessity of a further investigation for a possible rib fracture. On the other hand, rib fractures or even an isolated single rib fracture may cause severe pain with resultant limitation of deep breathing, subsequent atelectasis and pneumonitis. Moreover, unless detected and properly treated, rib fractures may become a life-threatening lesion particularly in elderly patients [4–6]. Thus, an accurate radiological examination and diagnosis of a rib fracture is of clinical significance in minor blunt chest trauma.

The sensitivity of conventional chest X-rays has been shown to be limited in showing rib fractures [7,8]. Moreover, chondral rib fractures are almost invisible on

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chest X-rays unless the fracture involves a strongly calcified cartilage [9]. Thus, more sensitive techniques are required to better evaluate the chest wall, and understand the etiology of pain in minor blunt chest trauma for a proper treatment to prevent possible pulmonary complications. Recently, transthoracic ultrasonography (USG) of the chest has been widely used in the evaluation of parenchymal, pleural, and chest wall diseases [10]. It has been suggested that USG was more sensitive in the detection of rib fractures including the chondral rib fractures compared with chest X-rays [7,9].

Although previous data outlined the clinical predictors of morbidity and mortality in traumatized patients with rib fractures [4,5,11–13], we are not aware of any previous report that has clarified the clinical predictors of the unnoticed rib fractures in minor blunt chest trauma. We conducted a study to investigate the possible rib fractures with USG, those overlooked on chest X-rays, and analyzed the possible clinical predictors of these insidious rib fractures in minor blunt chest trauma.

## 2. Patients and methods

### 2.1. Clinical features and management of the patients

A total of 37 consecutive patients with minor blunt chest trauma, admitted to the Hospital of Kırıkkale University School of Medicine between June 2001 and December 2002, were enrolled into this study. The patients were 27 (73%) male and ten (27%) female with a mean age of  $42.3 \pm 15.1$  years (range, 16–85 years).

Chest wall pain was the only presenting symptom in all patients which was aggravated by coughing, deep breathing and moving. The mean duration of the symptom was  $6.7 \pm 5.5$  days (range, 1 h to 27 days). The most common etiology of trauma was a fall in 19 (51.4%) patients followed by direct trauma in 12 (32.4%) patients, sports injury in five (13.5%) patients and vehicular accident in one (2.7%) patient. The site of the trauma was the right hemithorax in 24 (64.8%) patients, left hemithorax in 12 (32.4%) patients, and bilateral in one (2.8%) patient. Physical examination revealed tenderness on the affected site of the chest wall either with direct or indirect palpation during sternal compression. Three patients had ecchymosis on the traumatized site. None of the patients showed any evidence of rib fractures on chest X-rays.

All patients diagnosed to have rib lesions with USG, apart from one patient with subperiosteal hematoma and the patients admitted in the late period, were hospitalized with a mean duration of  $1.4 \pm 0.6$  (range, 1–3 days). An initial intercostal nerve block was performed in all patients with a local anaesthetic (0.5% bupivacaine HCl, Astra Zeneca, England). In addition, a combination of intravenous narcotic analgesic (Aldolan, Pethidine HCl 50 mg/ml, Gerot Pharmazeutika, Vienna, Austria) by

patient-controlled analgesia (PCA), and an intramuscular non-steroidal anti-inflammatory drug (Voltaren, Diclofenac sodium 25 mg/ml, Novartis Pharma Ag, Basel, Switzerland) were administered. All patients were discharged without any complication, and the treatment was continued with oral non-steroidal anti-inflammatory drugs and myorelaxants.

Most of the patients had 2 and 4 weeks repeat chest X-rays following discharge to detect the healing process of the fractured rib and a possible complication.

### 2.2. Evaluation with ultrasonography

All examinations were performed within the same day of admittance using linear 7.5 MHz probe (General Electric, Logic MD 400, Milwaukee, WI, USA). The most painful area with focal rib tenderness was examined in detail with the transducer aligned in the transverse position parallel to the long axis of the rib. Fractures of the ribs and associated subperiosteal hematomas were documented. A possible underlying visceral injury including the lung, liver, spleen, kidney, and the subdiaphragmatic space were also examined at the same USG session.

### 2.3. Definitions and statistical analysis

Age, gender, type of etiology, duration of pain, site of trauma, and involvement type of the rib were included in the statistical analysis. Age and duration of pain were classified as a high- or low-group relative to the median value. Type of etiology was stratified as fall or direct trauma to the chest. Site of the trauma was grouped as right or left hemithorax. Involvement type of the rib were dichotomized as bony rib fractures, and chondral rib fractures, the latter as to include either costochondral or chondrosternal separations. The logistic regression analysis was applied to clarify the impact of the clinical features on a possible rib fracture. Data were expressed as mean  $\pm$  the standard deviation (SD). A *P* value less than 0.05 was considered statistically significant. All statistical analyzes were performed with the Statistical Package for Social Sciences (SPSS, version 11.0, Chicago, IL, USA).

## 3. Results

A total of 15 (40.5%) patients showed rib lesions, whereas 22 (59.5%) patients had no rib lesions. The most common USG finding was the fracture of the rib associated with a subperiosteal hematoma in ten (66.7%) patients (Figs. 1 and 2) followed by the fracture of the rib alone in four (26.7%) patients (Fig. 3), and subperiosteal hematoma alone in one (6.7%) patient (Fig. 4). A total of eight (53.3%) patients had bony rib fractures, whereas seven (46.7%) patients had chondral rib fractures (Table 1). A total of two

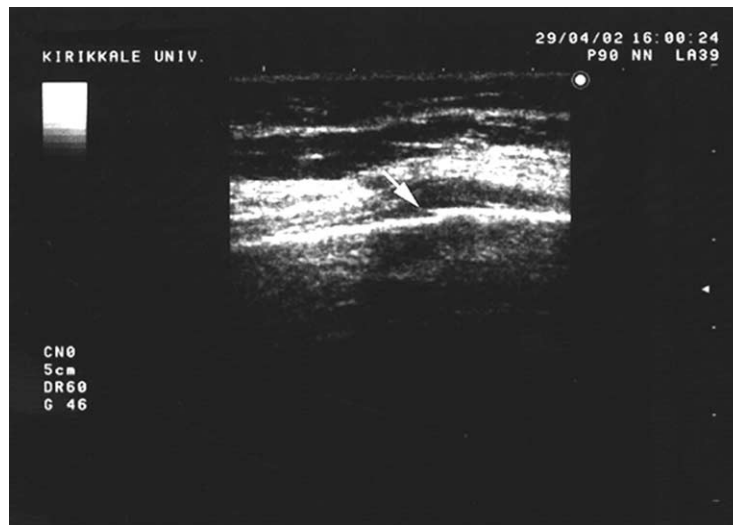


Fig. 1. Transverse sonogram of a 85-year-old woman with bony fracture of right eighth rib which reveals an undisplaced rib fracture (arrow) and a hypoechoic area consistent with a subperiosteal hematoma above the fracture line.

patients showed a limited hemothorax, which was evacuated with thoracentesis.

Age ( $P = 0.280$ ), gender ( $P = 0.431$ ), type of etiology ( $P = 0.823$ ), duration of pain ( $P = 0.470$ ), and site of trauma ( $P = 0.923$ ) were not significant predictors of rib fracture. However, the involvement type of the rib showed a significant correlation with age ( $P = 0.043$ ) and duration of pain ( $P = 0.036$ ). Bony rib fractures significantly occurred in elderly patients, whereas chondral rib fractures more commonly occurred in younger patients. The duration of pain in patients with bony rib fractures was significantly longer than that of patients with chondral rib fractures. The mean ages were  $54.2 \pm 13.8$ , and  $35.7 \pm 8.8$  years, and the mean durations of pain were  $10.5 \pm 4.5$ , and  $4.1 \pm 2.7$  days in patients with bony and chondral rib fractures, respectively.

#### 4. Discussion

Rib fractures occur with a rate of 35–40% in thoracic trauma, thereby making them the most significant finding in chest trauma [2]. Rib lesion occurs as a rib fracture, contusion, or both apart from the first and second ribs without any evidence of flail chest in minor blunt chest trauma according to the thoracic abbreviated injury scale (AIS) [3,14]. Early recognition of rib fractures is of clinical importance for the prompt initiation of an appropriate treatment. Physical examination may yield the diagnosis of a rib fracture when a crepitation is present, however, many patients with minor blunt chest trauma present without any physical or radiological findings apart from the tenderness on the affected site of the chest wall [3].



Fig. 2. Transverse sonogram showing an undisplaced rib fracture (arrow) and a subperiosteal hematoma in a 34-year-old man with chondral fracture of the right fourth rib.



Fig. 3. Forty-seven-year-old man with a bony fracture of right seventh rib, in which the sonogram shows a displaced rib fracture (arrow).

A chest X-ray is the initial step in radiological examination of a possible rib fracture and an associated complication. A low-kilovoltage X-ray can be obtained to outline the bone detail in cases with symptoms highly suggestive of rib fractures but showing no evidence on chest X-rays [7]. The diagnosis of a rib fracture may easily be overlooked unless it presents with an apparent dislocation at the fracture site [3]. Furthermore, thoracic surgeons are aware that a rib fracture, which is undiagnosed at a previous chest X-ray taken during inspiration, can be diagnosed at another instance with a chest X-ray taken during expiration. These findings imply the significance of the patient's position and the interval of the respiration that the X-ray is taken. Likewise, oblique chest X-rays have also been shown to be unnecessary in the evaluation of chest trauma [15]. These radiological features indicate that the use of chest X-rays solely to detect rib fractures appear to have little value in blunt chest trauma. Moreover, above findings might explain as to why up to 50–88% of rib fractures go

undetected on conventional chest X-rays [7,8]. We found that 40% of patients with minor blunt chest trauma had undetected rib fractures on chest X-rays, which was revealed with USG. Nevertheless, our analysis could not have clarified a significant clinical predictor for these insidious rib fractures. On the other hand, cartilage fractures cannot be diagnosed with conventional chest X-rays and the diagnosis of either costochondral or chondrosternal cartilage fracture is essentially based on clinical findings. Thus, patients with cartilage fractures who present with long standing pain may be considered as malingerers because the diagnosis may easily be overlooked unless the physician can palpate the crepitation or slipping of the cartilage over the bony part of the rib, which implies the necessity of a more sensitive diagnostic method for showing the cartilage fractures.

USG has been advocated to be useful in detecting rib fractures in chest wall trauma, and its sensitivity rate reaches up to 78% compared with 12% detected on chest



Fig. 4. Sonogram of the right fifth rib in a 25-year-old man showing a subperiosteal hematoma (arrow), but no evidence of rib fracture.

Table 1  
Clinical and radiological features of patients showing rib lesions revealed by ultrasonography

No. of patient	Age	Gender	Etiology	Duration of pain (day)	Localization of trauma	Involvement type of the rib <sup>a</sup>	Lesion of the rib <sup>b</sup>
1	49	M	Fall	14	Left 8 lateral	B	F
2	35	M	Direct trauma	3	Left 3 anterior	C	F + SH
3	40	M	Direct trauma	2	Right 8 anterior	C	F + SH
4	47	M	Fall	10	Right 7 lateral	B	F
5	53	M	Direct trauma	3	Right 6 anterior	C	F
6	42	M	Fall	10	Left 4 lateral	B	F
7	31	M	Fall	2	Left 3 anterior	C	F + SH
8	85	F	Fall	9	Right 8 lateral	B	F + SH
9	34	M	Fall	5	Right 4 anterior	C	F + SH
10	25	M	Direct trauma	4	Right 5 anterior	C	SH
11	32	M	Fall	10	Right 2 anterior	C	F + SH
12	52	F	Direct trauma	7	Left 4 posterior	B	F + SH
13	48	M	Fall	6	Right 6 lateral	B	F + SH
14	48	M	Fall	20	Right 11 posterior	B	F + SH
15	63	M	Direct trauma	8	Right 2 anterior	B	F + SH

<sup>a</sup> B, bony rib fracture; C, chondral rib fracture.

<sup>b</sup> F, fracture; SH, subperiosteal hematoma.

X-rays [7,9]. Likewise, USG has been shown to be more sensitive in the detection of chondral rib fractures and cartilage separations compared with chest X-rays [9]. USG can visualize the costal cartilage as well as the osseous part of the rib, and unlike radiography or bone scintigraphy it avoids ionizing radiation. In addition, unlike computerized tomography, USG can examine each rib parallel to its long axis, and unlike magnetic resonance imaging, USG is not affected by respiratory motion. As a non-invasive imaging technique, USG is also advantageous for its easy transportation and rapid examination [7]. Furthermore, the imaging of a rib fracture with USG is not a complicated procedure, and can even be performed by the clinicians as well. However, USG may be inaccessible for the subscapular ribs and the infraclavicular portion of the first rib, which are uncommon sites for rib fractures. In addition, large breasts and obesity may also limit the optimal detection of rib fractures [7].

The localization of the fractured rib is of clinical significance to further evaluate a possible associated visceral injury. Fractures of the first three ribs usually indicate significant trauma to the trachea, bronchi and main vascular structures. Likewise, fractures of the lower ribs should arouse suspicion for a possible injury to spleen, liver, kidneys or diaphragm. In our series, two patients showed a limited hemothorax at the same USG session performed for the rib fractures. We evacuated the blood in these patients, which might otherwise result in pleural thickening, and possibly chronic pain caused by the adhesions.

Rib fractures usually occur at the fourth through tenth ribs, and are more often seen in adults in whom the osseous structures are less resilient [12,16]. It has been shown that the mortality rate from isolated rib fractures was as high as 10–20% in the elderly, which implies the significance of

diagnosis and adequate treatment of rib fractures in elderly patients [6]. Elderly patients are more subject to the fracture of the bony part of the rib, however, chondral rib fractures relatively occur in younger patients compared with elderly patients [9]. Similarly, our data revealed that elderly patients significantly had bony rib fractures, whereas younger patients had chondral rib fractures.

Even an isolated single rib fracture may cause severe pain, thereby resulting in labor loss and low quality of life. Thus, accurate clarification of a rib fracture is an essential prerequisite in designing better treatment protocols. Treatment of rib fractures should be directed toward the relief of pain and prevention of a possible atelectasis, unless the rib fracture complicates an intrathoracic injury or flail chest. Although soft tissue injuries are very likely to be treated with non-steroidal antiinflammatory drugs and muscle relaxants, more significant thoracic injuries such as rib fractures may require parenteral narcotics. Alternative methods for controlling pain resulting from rib fractures include a wide range from intercostal nerve blocks, intercostal-intrapleural catheter analgesia, epidural catheter analgesia, to transcutaneous electric nerve stimulation in thoracic trauma [3,17,18]. If we could not have diagnosed the patients with rib fractures, we would conventionally treat these patients with non-steroidal antiinflammatory drugs, however, we managed all patients with rib fractures using parenteral narcotic analgesics in addition to non-steroidal antiinflammatory drugs following an initial intercostal nerve block in our series. An effective and proper treatment of rib fractures is of clinical significance to prevent possible complications, and we observed no complication in our series.

A high rate of rib fractures, which are overlooked on chest X-rays, occur following minor blunt chest trauma. Suspicion should arouse for a possible rib fracture

particularly in elderly patients with long-standing chest wall pain. USG is highly sensitivity in showing these insidious rib fractures. An accurate diagnosis with proper treatment of rib fractures will prevent pulmonary complications.

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